DEC STD 103-3 Electromagnetic Compatibility (EMC) - Electromagnetic Interference (EMI) Requirements

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ABSTRACT: This standard defines Electromagnetic Interference (EMI) requirements for Digital products that comply with mandatory external EMI requirements (for instance in the US, Canada, European Community, and Japan). This document also includes information on the test methodologies and the internal (Digital) EMI approval process.

NOTE

The requirements shown in this standard were previously included in DEC STD 103-0 Rev B.

APPLICABILITY: The requirements of this standard are mandatory for the design of all Digital hardware products. Volume manufactured devices and systems that were approved according to DEC STD 103 Rev B (29-Aug-1986) must be redesigned and requalified to meet the technical requirements of this standard before 01-Jan-1992. For those devices that will not be manufactured on or after 01-Jan-1992, no redesign or requalification is required. Products first released to Manufacturing or with a FCS date on or after 01-Aug-1990 must meet the requirements of this standard.

STATUS: APPROVED 11-Jul-1990; use VTX SMC for current status.

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1 INTRODUCTION

This section of *DEC STD 103 Electromagnetic Compatibility (EMC)* defines the following.

a. Digital's internal requirements complying with external, legal electromagnetic interference (EMI) requirements.

b. Instrumentation and test processes.

c. Limits for electromagnetic emissions.

d. Documentation and licensing requirements, which are further detailed in *DEC STD 103-1 EMC Documentation and Approval Process*.

e. A required quality assurance plan according to *DEC STD 103-7 Electromagnetic Compatibility (EMC) Quality Process, proposed*.[1]

This section applies to the following categories.

- All products that are offered for sale to customers by Digital.
- Products that are used by Customer Service on customer premises as part of the installation.
- Products used at the integration level that correspond to actual user installations, as well as to certain component level products as defined below.

  I/O modules that can be interchangeably mounted, for example, Q-bus, BI Bus
  Low voltage powered devices, for example, keyboards

In all cases, products must be tested in a system level configuration as defined in heading 3.

1.1 SCOPE OF COMPLIANCE

Compliance to the EMI requirements of this standard ensures compliance to the following external standards.

CSA 108.8	Electromagnetic Emissions from Data Processing Equipment and Electronic Office Machines
EEC Directive 89/336	Note that other standards must be met to satisfy this directive, such as *DEC STD 103-4 Electromagnetic Compatibility (EMC) - Electromagnetic Susceptibility (EMS) Immunity Control, proposed* and *DEC STD 103-5 Electromagnetic Compatibility (EMC) - Hardware Design Requirements for Prevention Of or Protection Against Electrostatic Discharge (ESD), proposed*
EN55022 and National standards based on these, such as:	BS6527 (UK) NEN55022 (Netherlands) DIN VDE 0878 part 3 (Germany)

[1] This section of DEC STD 103 is under development. Use VTX SMC to verify this document's availability. Contact your EMC Domain Manager for the most recent information.

FCC Rules, Part 15 (1989)	FCC Rules and Regulations, Part 15 Radio Frequency Devices, Subpart J Computing Devices
Standards Australia AS 3548-1988	
Japan VCCI level 0	

Similar standards for electronic data processing and office machines based on CISPR-22 are under development in other countries. As they become defined, they will be added to the list.

NOTE

In some countries, external agency submittal of paperwork and/or products is required to obtain legal approval or market acceptance. Organizing this external submittal is the responsibility of the Digital country or marketing organization involved.

In most cases, there are two defined levels of compliance, called A or B, or sometimes Class I and II.

A product is considered in compliance with this standard after the EMC test report (see heading 5) has been signed off by the responsible EMC domain engineer and the person responsible for bringing the product to market, and the report has been submitted to the EMC domain office. It is the responsibility of the person obtaining Product Authorization Committee (PAC) approval for the product (usually the product manager) to sign the report, unless it is specifically decided otherwise.

Requirements under this section of this standard cannot be waived either for product design or manufacturing. The product business plan must define either Class A or Class B as a design criteria for the product.

A product may be defined as Class B in one market area and Class A for the same product in another market area. Class B is recommended as a design goal for all table-top equipment.

Certain specialized devices that incorporate computers that do not normally fall within Digital's product spectrum are exempted from meeting FCC part 15 requirements. Information concerning these devices and exemptions is available from the EMC domain.

2 INSTRUMENTATION AND TEST SITE REQUIREMENTS

The following subheads describe the instrumentation and physical test site requirements to perform tests mentioned in this standard. Refer to ANSI C63.4, *Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz*.

2.1 EMI TEST INSTRUMENTATION

General - All test equipment, including test sites, must be calibrated according to the requirements of *DEC STD 103-2 Electromagnetic Compatibility (EMC) - Calibration of Test Facilities and Instrumentation, proposed*.[1]

Miscellaneous items will also be needed, such as coaxial cables, connectors, adapters, and attenuator pads. For frequencies under 30 MHz, RG58 and BNC connectors are acceptable. For higher frequencies, N connectors and a low-loss coaxial cable are recommended.

LISN (Line Impedance Stabilization Network) - Each ac power cord from the device or group of devices under test shall terminate in a CISPR-3 LISN with an extended frequency range (to 30 MHz). Calibration requirements for LISNs are defined in DEC STD 103-2.

For systems with multiple power cords, at least two LISNs are necessary. In terms of ease-of-use and time, the optimum test is achieved when each power cord terminates in its own LISN. As a minimum, a test site should have two LISNs suitable for the maximum current load to be expected.

Ground Impedance - All EMI testing shall be done with the safety-ground wire of the equipment's ac power connector connected to the RF groundplane of the test site, except as noted below.

For 50 Hz/240 V devices that have a margin of less than 6 dB to the conducted limit, the safety ground of each tested system's power cord, in succession, shall be connected via a 50 Ohm/1.5 mH inductor to the RF groundplane. The appropriate limit(s) must also be met in this condition.

Antennas - Radiated measurements for frequencies over 30 MHz are made with calibrated, linearly polarized antennas, the length of which does not exceed that of a tuned dipole at 80 MHz. Multiple antennas may be needed to cover the desired frequency range. Radiated measurements for frequencies under 30 MHz are made with a magnetic loop antenna.

Receiver or **Spectrum Analyzer** - The radio frequency noise voltages are measured with an EMC receiver according to CISPR-1, 2, 2A, and 3; for measurements above 1 GHz, an average detector shall be used. For engineering evaluation, a spectrum analyzer is an extremely useful tool. However, care must be taken not to overload the spectrum analyzer input:

During steady-state conditions with the residual 50 or 60 Hz current from the LISN RF port

During transient conditions (switching of the equipment under test) with the available transient energy

[1] This section of DEC STD 103 is under development. Use VTX SMC to verify this document's availability. Contact your EMC Domain Manager for the most recent information.

Or with signals from strong (local) radio/TV transmitters

Usually 10 to 20 dB padding is required to protect spectrum analyzers when connected to a LISN.

Clamp - A clamp is necessary for measuring interference power. They are available from Rohde & Schwarz (Polarad) and Fisher communications.

2.2 CONDUCTED EMI TEST SITE

The preferred test area to measure conducted emanations from products is a shielded enclosure (screen room) with a filtered ac power source, with the ambient noise at least 20 dB below the values to be measured. The screen room should be designed such that its ambient noise is 20 dB below the worldwide Class B requirements.

An alternate site is a ground plane that exceeds the footprint of the device (or group of devices) to be tested by at least 1 meter in each direction.

The area around and above the equipment to be tested must be free of metallic (conducting) objects for at least 80 cm. The LISNs and the measurement instrumentation shall have a RF bond to the reference plane (either the screen-room ground or the ground plane under the equipment). Ground straps must be made of foil or braid, and must be at least ten percent of their length in width to provide a sufficiently low impedance. The 1.5 mH inductors in the safety ground circuit may be built into the LISNs or connected in series with the equipment power cord. These inductors must provide a high (more than 1000 ohm) impedance for the frequency range of 150 kHz to 30 MHz.

Calibration requirements for conducted test sites are defined in DEC STD 103-2.

2.3 RADIATED EMI TEST SITE

In order for a test from this site to be considered for qualification, the site calibration report must be on file in the EMC domain office and the site must meet the calibration requirement of DEC STD 103-2 and ANSI C63.4.

The preferred radiated EMI test site is a 10 meter free field, calibrated to the requirements of DEC STD 103-2. For some measurements (such as magnetic field strength, VDE Class A and C) it may be necessary to use a test site with a distance of 30 and 100 meters to obtain data for agency submittal.

NOTE

For some equipment classes (such as Class B certified personal computers), the FCC requires acceptance of the test site before the test data can be considered valid.

3 TEST PROCESS

The test process deals with the physical arrangement of the equipment under test, the electrical (power and data) connections, and the EMI measurement process. This process is based on the relevant CISPR, VDE, and FCC documents for emission testing of EDP and office equipment.

The test procedures must conform to ANSI C63.4. More detailed procedures for testing and equipment set-up will be defined by the EMC Domain Office when required.

3.1 OPERATION OF THE DEVICE(S) UNDER TEST

The system shall be operated in a manner simulating actual (that is, typical) use. As a rule, an operating system such as VMS, ULTRIX, or MS-DOS shall be used. The device under test shall be fully exercised. The emission test shall be performed with the device and accessories configured in a manner that tends to produce maximized emissions within the range of variations that can be expected under normal operating conditions. All I/O ports (memory, terminals, disks, tapes, and so forth) shall be exercised by creating data streams from the CPU to the peripheral(s). For the purposes of the test, it is not important that the software checks for reliable operation. For the convenience and speed of this test, it is important that each I/O channel receives a data burst of at least 1 ms, and that the I/O process repeats itself in full every 1 second or less. Data content is not of primary importance and the data shall normally be a quasi-random sequence.

Specific data streams or settings for user controls are defined for certain devices in ANSI C63.4, section 4.3.1.1.1.

4 ACCEPTABILITY CRITERIA (LIMITS)

4.1 MARGINS REQUIRED FOR COMPLIANCE

For devices that meet the requirements of this revision or will continue to be marketed after 01-Jan-1992, compliance is based on the principle of establishing an 80% confidence factor that 80% of the production units will pass the limits.

The following three methods are acceptable to demonstrate this.

- Qualification will be based on demonstration that the device is capable of meeting the CISPR 80/80 criteria (80% of the products comply with the limits with an 80% confidence factor) according to the following table and formula, based on CISPR Recommendation 46/1, *Significance of a CISPR Limit*:

Number of Units Tested	3	4	5	6	7	8	9
K Factor	2.04	1.69	1.52	1.42	1.35	1.30	1.27

  Average level (per frequency) + KS(n) $\leq$ Guardband Limit

  Where S(n) is the sigma of the normal distribution of (n) samples.

- Alternatively, 80/80 compliance may be shown by testing a random sample of seven units in which none of the units may exceed the limit.
- If a single type-tested device has a worst case margin of 6 dB, it is assumed to meet the CISPR 80/80 criteria without further testing.

4.2 GENERAL REQUIREMENTS

Tables 1, 2, and 3 reflect the maximum allowable EMI emanations from products sold by Digital. These levels are relevant for cabinet level entities, freestanding peripherals, terminals, and systems, and they reflect the composite worst case limits defined by regulatory authorities in Digital's major market areas. In general, the test methodology defined in ANSI C63.4 shall be followed. Lower limits apply at transition frequencies.

NOTE

For products that are limited in volume or for certain geographic areas, different margins or limits may be agreed to and negotiated by the Product Manager and the EMC Domain Manager, and the results of the negotiation shall be documented in the business plan. In no case shall the product specifications be in conflict with the legal requirements of the country.

All products shall be measured (regardless of the applicable limits) between 10 kHz and 30 MHz for conducted emissions and between 30 MHz - 1000 MHz for radiated emissions.

For devices with a highest clock frequency of 108 MHz or more, radiated measurements shall be made up to 2000 MHz. If the highest clock frequency is more than 500 MHz, measurements shall be made up to at least 5000 MHz.

4.2.1 Limits of Mains Terminal Voltage

The test unit shall meet the limits defined in Table 1, including the average limit and the quasi-peak limit, when using an average detector and a quasi-peak detector, respectively. If the average limit is met when using a quasi-peak detector, the test unit shall be deemed to meet both limits, and measurement with the average detector is unnecessary.

If the reading on the measuring receiver shows fluctuations close to the limit, the reading shall be observed for at least 15 seconds at each measurement frequency. The highest reading shall be recorded, with the exception of any brief isolated high reading which shall be ignored.

Table 1: Limits of Mains Terminal Voltage for Class A and Class B Equipment from 0.15 to 30 MHz

Frequency range (MHz)	Limits dB (μV) Quasi-peak	Average
Limits for Class A Equipment		
0.15 to 0.50	79	66
0.50 to 30	73	60
Limits for Class B Equipment		
0.15 to 0.50	66 to 56[1]	56 to 46[1]
0.50 to 5	56	46
5 to 30	60	50

[1]The limit decreases linearly with the logarithm of the frequency.

4.2.2 Limits for Telecommunication Signal Lines

Telecommunication signal lines are communication and/or control signal lines that are:

a. Intended for connection to a public telecommunications network (PTT network such as PSTN or ISDN).

b. Potentially longer than 10 meters according to the manufacturer's system configuration requirements AND do not connect parts of the actual system under test (the cables leave the test area). LAN cables normally fall under this category.

Symmetrical, balanced transmission cables with up to two balanced pairs are to be measured using T-Impedance Stabilization Networks (T-ISNs) as defined in VDE 0878. The 9.5 dB loss of the T-ISN must be added to this measurement (plus any other correction or loss factors introduced in the measurement system).

All other communication cables are measured by placing a RF current probe over the cable within 10 cm of the connector and cabinet. The impedance at the far end of the cable must be stabilized at 150±20 ohms to ground for unshielded cable or 50±5 ohms for shielded cable. For shielded cable, the 50 ohm impedance refers to the impedance from the shield to the reference ground as presented by the ISN.

When it is not possible or practicable to construct an ISN, at least 10 meters of the telecommunications cable shall be placed at a distance of five centimeters above the ground plane. The first three meters need to run in a straight line from the equipment under test, and the remaining seven meters can be folded back and forth in a non-inductive pattern.

In Table 2, the lower limit shall apply at the transition frequency. The limit decreases linearly with the logarithm of the frequency in the range .15 to .50 MHz. The voltage limits refer to measurement with a T-ISN, the current limits to measurement with a current probe.

Table 2: Limits for Telecommunication Signal Lines: Class A and Class B

	Class A			
	Limits			
Frequency Range (MHz)	Quasi-peak		Average	
	dB (μA)	dB (μV)	dB (μA)	dB (μV)
.15 to .50	53 to 43	97 to 87	40 to 30	84 to 74
.50 to 30	43	87	30	74

	Class B			
	Limits			
Frequency Range (MHz)	Quasi-peak		Average	
	dB (μA)	dB (μV)	dB (μA)	dB (μV)
.15 to .50	40 to 30	84 to 74	30 to 20	74 to 64
.50 to 30	30	74	20	64

4.2.3 Limits of Radiated Field Strength

This subhead describes the limits for radiated field strength. Use the process described in subhead 4.2 to perform these measurements.

Table 3: Limits of Radiated Field Strength for Class A and Class B Equipment

Class A: test distance 10 meters	
Frequency range (MHz)	Quasi-peak limit dB (μV/m) 10 meters
30 to 88	39.1
88 to 230	39.5
230 to 1000	46.5
above 1000	49.5

Class B: test distance 3 and 10 meters[1]		
Frequency range (MHz)	Quasi-peak limit dB (μV/m)	
	10 meters	3 meters
30 to 88	30	40
88 to 216	30	43.5
216 to 230	30	46
230 to 1000	37	46
above 1000	N/A	54

[1]Both the limits at 3 and 10 meters must be met for a worldwide product.

4.3 COUNTRY SPECIFIC REQUIREMENTS

Germany: During the time between the effective date of this standard and the mandatory implementation date of the European Community (EC) directive on EMC (01-Jan-1992), additional requirements for Germany based on the current legislation (DBP Directive 523/1969) must be followed.

These requirements are applicable to all product tests for qualification of new devices or systems, tests to qualify engineering changes (ECOs), or system configuration changes for products that are to be marketed in Germany.

The additional requirements are defined in DIN VDE 0878 part 30 that is available from the EMC domain office upon request.

5 DOCUMENTATION AND LICENSING REQUIREMENTS

The test facility or group performing the EMC testing on a product is responsible for documenting the equipment tested for the test purpose and repeatability, the test process used, and the results obtained in a standard form as defined in DEC 103-1 and in conformance with ISO Guide 45, *Guidelines for the Presentation of Test Reports*.

The test report must be signed by:

1. The Test Engineer or technician performing the test, attesting to the validity of the results
2. The Test Group Manager, attesting that the product underwent all the required tests and that all the relevant information is reported
3. The person responsible for bringing the product to market, attesting that the product tested is representative of what is being marketed
4. The person writing the report, if different from any of the above

The EMC domain office must receive a copy of the completed report before the product can be considered a low risk for product announcement from a EMC-Regulatory point of view.

6 QUALITY ASSURANCE REQUIREMENTS

A Quality Assurance Plan (QAP) provides for a controlled test on randomly selected product samples obtained from manufacturing. Each volume manufactured product must have a QAP that documents how to re-establish the compliance to the product's limits, based on one year's production.

A QAP must be proposed by the EMC design group and agreed to by the Manufacturing Quality Assurance (QA) group of the major supplier plant before the engineering release for the product.

Once agreed to, this Manufacturing QA group becomes the owner of the QAP and is responsible for executing the requirements of the plan. to by the Manufacturing Quality Assurance (QA) group of the major supplier plant before the engineering release for the product.

Once agreed to, this Manufacturing QA group becomes the owner of the QAP and is responsible for executing the requirements of the plan.

QAP plans may be modified during the product life based on experience gained in QA Production (audit) testing. It is recommended that the QAP and the associated product tests be kept together in one file so that an EMC history of the product is readily available.

Detail requirements for such a QAP are defined in DEC STD 103-7 (proposed).

APPENDIX A REFERENCED DOCUMENTS

A.1 EL-Class Digital Documents

EL-Class Number	Document Title
EL-00103-01	*DEC STD 103-1 Electromagnetic Compatibility (EMC) - Documentation and Approval Process*
EL-00103-02	*DEC STD 103-2 Electromagnetic Radiation (EMC) - Calibration of Test Facilities and Instrumentation*
EL-00103-04	*DEC STD 103-4 Electromagnetic Compatibility (EMC) - Electromagnetic Susceptibility (EMS)*
EL-00103-05	*DEC STD 103-05 Electromagnetic Compatibility (EMC) - Hardware Design Requirements for Electrostatic Discharge (ESD) Immunity, proposed*
EL-00103-07	*DEC STD 103-7 Electromagnetic Compatibility (EMC) - Quality Process*

Use VTX SMC to order copies of EL-class documents from Standards and Methods Control. Send distribution questions to JOKUR::SMC or call DTN: 234-4423.

A.2 Other Documents

Document Number	Document Title
ANSI C63.4	*Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (proposed)*
BS6527	*Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment*
CFR 47 PART 15	*FCC Rules and Regulations, Part 15 Radio Frequency Devices*
CISPR REC. 46/1	*Significance of a CISPR Limit*
CISPR-1	*Specifications for CISPR Interference Measuring Apparatus for the Frequency Range of 0.15 MHz to 30 MHz*
CISPR-2	*Specification for CISPR Radio Interference Measuring Apparatus for the Frequency Range 25 Mc/s to 1000 Mc/s*
CISPR-22	*Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment*
CISPR-2A	*First Supplement to CISPS Publication 2*
CISPR-3	*Specification for CISPR Radio Interference Measuring Apparatus for the Frequency Range 10 kHz to 150 kHz*
DBP DIR. 523/1969	*Law on the Operation of High Frequency Equipment*
DIN VDE 0878 PART 3	*Electromagnetic Compatibility of Information Technology and Telecommunications Equipment; Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment (CISPR 22, modified)*
DIN VDE 0878 PART 30	*Electromagnetic Compatibility of Information Technology and Telecommunication Equipment; Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment; Suppl. to DIN VDE 0878 Pt.3*

Document Number	Document Title
EEC DIR. 89/336	*Council Directive of 3 May 1989 on the Approximation of the Laws of the Member States Relating to Electromagnetic Compatibility*
ISO/IEC GUIDE 45	*Guidelines for the Presentation of Test Reports*

A.3 Ordering Information

Following are the sources for documents not available from Standards and Methods Control.

NOTE

All documents are available from the EMC Domain Office.

- American National Standards Institute (ANSI),
  1430 Broadway, New York, NY 10018
  Telephone (212) 354-3300 x479
- Comité International Spécial des Perturbations Radioélectriques (CISPR)
  (International Special Committee on Radio Interference)
- International Standards Organization (ISO)
  Contact Low End Regulatory Engineering, MLO6-1/U30
- US Government Printing Office
- VDE-Verlag GmbH, 1 Berlin 12, Germany
  or
  Technical Help to Exportes, British Standards Institution,
  Marylands Avenue, Hemel Hempstead, Herts, England
- Voluntary Committee for Control of Interference
  Contact Low End Regulatory Engineering, MLO6-1/U30

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